

# Two paths from the same place: Task driven and human-centered evolution of a group information surface

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## Abstract

This is the tale of two different implementations of a collaborative information tool, that started from the same design source. The Blueboard, developed at IBM Research, is a tool for groups to use in exchanging information in a lightweight, informal collaborative way. It began as a large display surface for walk-by use in a corporate setting and has evolved in response to task demands and user needs. At NASA, the MERBoard is being designed to support surface operations for the upcoming Mars Exploration Rover Missions. The MERBoard is a tool that was inspired by the Blueboard design, extending this design to support the collaboration requirements for viewing, annotating, linking and distributing information for the science and engineering teams that will operate two rovers on the surface of Mars.

The ways in which each group transformed the system reflects not only technical requirements, but also the needs of users in each setting and embedding of the system within the larger socio-technical environment.

Lessons about how task requirements, information flow requirements and work practice drive the evolution of a system are illustrated.

## 1. Introduction

The best solutions evolve in response to user needs. This paper is a telling of how a single idea – the large, public interactive display – evolved from a single origin into two different systems in response to the varying demands of different communities and their patterns of use.

BlueBoard began at IBM's Almaden Research Center in midyear 2000 as a way to connect researchers who wanted to look at web-based information in a very fast, simple-to-use setting. Not long afterward, researchers (Trimble & Wales) saw a BlueBoard demonstration and realized that the idea of a large, sharable, interactive display would solve information sharing and joint work tasks that emerge in space mission coordination.

We have been working together ever since to share ideas and technology, and have seen how each of the two instances of the same idea have evolved over time.

To tell the story, we first examine the BlueBoard, its original goals and then turn our attention to MERBoard, goals of its development and initial pilot studies. In the last section we draw lessons learned from common interests in two very similar projects that vary because of interestingly varied user populations. The comparison between BlueBoard and MERBoard gives a good insight into the ways in which user-centered design practices can dramatically vary the design and implementation of a solution for users.

## 2. BlueBoard: Original Goals

The BlueBoard is a large, interactive display surface based on a 1.3 meter plasma display (XGA) with a resistive touch screen (from SMART Technologies [8]) and a badge reader for personal identification (an HID brand RFID reader connected to the serial port [5]), with a laptop PC secured in a lockbox bolted to the rear of the display, running the BlueBoard thin client software. Similar systems have been constructed and used for a variety of purposes – from point-of-sale to information kiosks. [1, 2, 3, 4]

In ordinary use, the BlueBoard is intended for both very fast personal use (walk up, check your calendar, walk away – all within 5 seconds), and for small group collaborative use (a small number of people stand around the BlueBoard to sketch ideas, pull up information from their personal space, compare notes, share content, create something new). Originally, the BlueBoard was primarily intended for the first role – rapid use; but it has since evolved to become more of the latter – a social collaborative mechanism.

In our design, a BlueBoard has no keyboard or mouse. While this seems restrictive, our goal is not to have BlueBoards become just another personal computer – it is consciously intended to support lightweight, fast encounters and simple spontaneous collaborative meetings. We do not believe that providing full keyboard capability (and corresponding security control problems) works to the BlueBoard's advantage.

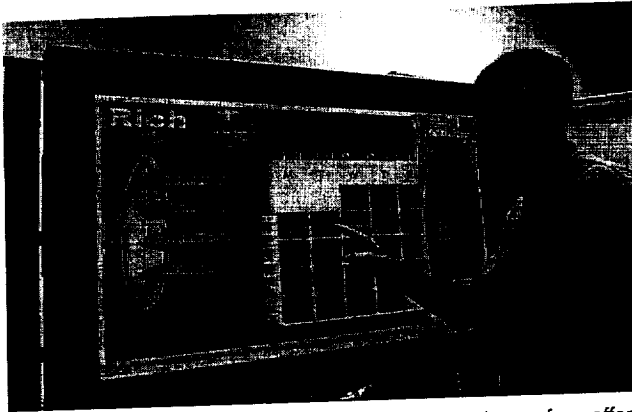


Figure 1. The BlueBoard is a large, interactive display surface offering fast access to personal information with tools for collaboration and small groups of people working side-by-side. The display has a touch screen overlay and a badge reader on the right corner for person identification. Network access is assumed.

In the BlueBoard, the badge's unique identifier is sent to a Badge Server database that authenticates the user, handing back a URL to that person's personal content.

The act of swiping your badge by the reader brings up a representation of the badge owner in a column on the right hand side of the large display (see Figure 2). A "personal icon," or *p-con*, is created on the BlueBoard display off on the side in the tools area. Note that a person's "home page" is not immediately displayed, but becomes available only by explicitly touching one's p-con.

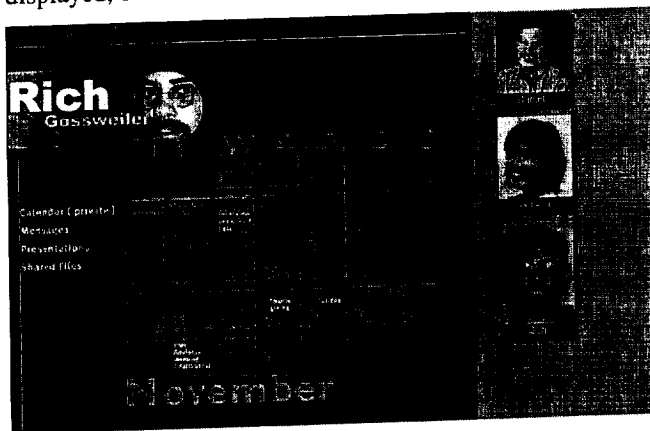


Figure 2. A typical BlueBoard personal display. This kind of content is set up by each user as their "home content." Content displayed on the BlueBoard can be shared with another person by dragging the content (window, image, URL) to their p-con. Here, Rich is showing his home page calendar to Daniel and Alison.

Clearly, such content needs to be created by the user. It's important to note that the BlueBoard system is not yet-another attempt to solve the web-site authoring problem, but rather simply presents information that is created elsewhere, linking high-value information to web content.

We are currently working towards a simplified BlueBoard content authoring tool, one that provides very simple templates to link personal content to the BlueBoard server. While not intended to be used at the BlueBoard, simple content creation is part of the entire BlueBoard use cycle. (The discussion of such a content creation tool is beyond the scope of this paper.)

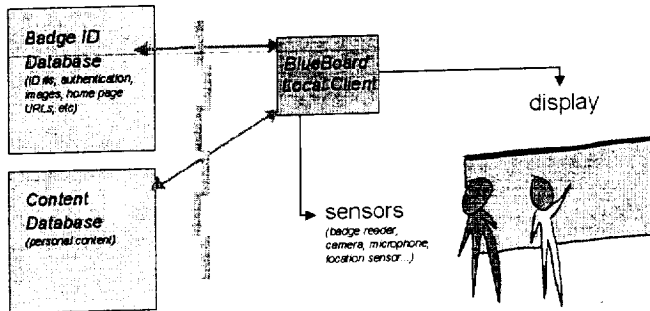


Figure 3. A BlueBoard links backend content (on a webserver) with presentation on the large plasma display with touchscreen and badge reader. The badge ID is sent off for authentication, returning either an "unknown user" error, or an authenticated set of URLs in the Content Database. The effect is that a user "logs in" by simply swiping their badge at the display, getting rapid access to their content.

### ***Appliance Design for Personal vs. Communal Uses***

There's an inherent design tension in large public displays: they are good for group work with peers standing shoulder-to-shoulder, working together, but they are also very handy for rapid personal, one-person information access. Unlike other information appliances, these devices must support both single users and multiple users. It needs to work for a single person walking up to the BlueBoard to check their calendar, and it needs to work for small groups of people working together. Consequently, there are two very different sets of overall goals: design the BlueBoard for individual information access, and design the BlueBoard for multiple people using the display at the same time.

We have come to recognize that several design points need to be satisfied to balance these competing design goals. These basic design issues are: (1) representing a person who's participating in a session at the BlueBoard, (2) providing adequate tools for use at the board (e.g., a whiteboard function, a map of the area, etc.) and (3) keeping personal information private while making location-based information available.

## **2.1 BlueBoard in Use**

### ***Representing a person: P-cons for access & sharing***

When more than one person is using the device, the device needs to know whose content is being viewed. There also needs to be a way to easily share content among the users who are all using the board at the same time.

The *p-con* is just an image of the person representing that person's content. When a badge is swiped, a person's *p-con* appears in the *p-con* dock on the right side of the display (see Figure 2). When more than one person is at the board, all of their *p-cons* show up on the display (currently up to six).

The *p-con* becomes the rapid access point for personal content. A user sets up their content ahead of time, linking items such as calendars, presentations, continually updated information (stock quotes, project status, etc.) to the home page. Then, once badged-in to the BlueBoard, a finger touch on the *p-con* brings up the first page of their content.

The *p-con* is also the way to share information between simultaneous users. If one user is showing a slide from their content or an especially interesting web page, a drag-and-drop movement from the page to a *p-con* will deposit a copy of that content in the *p-con*. When the *p-con*'s person badges out (leaves the BlueBoard session), the contents of the *p-con* is e-mailed to them. In this way, sharing information is extremely simple – when you see something you like, just drag it to the *p-con* and the content is shared.

Since all content shown on the BlueBoard is some variant of a web page, dragging an individual item (e.g., a block of text or a picture) just copies that item into the person's temporary p-con buffer. To make a copy of the entire page, the user will drag from a "whole page" handle (the title bar) to the p-con.

In essence, the p-con stores content until the user badges out. At badge out time, the contents of the p-con buffer are packed up into an email message and sent off to the p-con owner's email space.

We have consciously avoided overly complex mechanisms such as group management or automatically trying to move the p-con buffer contents into their personal content web. An important goal is that the BlueBoard be usable with a tiny amount of training. Currently, to simplify things, only people present can share content, and sharing is done by logically moving shared material into their email. In a similar vein, we've attempted complex window management schemes for doing split screens, but have not yet been able to devise a way that allows the split screen to be simple to explain and use. It's too easy to become confused between foreground and background. Since an overriding goal is simplicity, we continually return to those roots in making design choices.

### ***Tools for Rapid Use in Place***

Public, shared, communal devices all need to be extremely simple to use and must be intrinsically useful even without special registration. We want people to be able to simply walk up to a BlueBoard and do useful work.

To date we have built a simple toolbar that allows a passerby to gain immediate access to several functions: a whiteboard sketching tool, a calendar that shows the current day / week / month, and a local map (showing the location of the BlueBoard in the local building).

These functions continue to be accessible after badging in as well. As with all other content shown on the BlueBoard, this content can be dragged to a p-con for sharing via an email connection.

### ***Transient Information Must Be Truly Transient***

When a user badges in to the BlueBoard, their content flows to that location. When they badge out, the content stored in the p-con buffer (if any) is emailed to the email address of their choice (pre-specified at BlueBoard user registration time). But equally importantly, any content that was pulled to the BlueBoard from the remote content server must be purged from the local system to avoid the possibility of compromise by later walk-up users.

To make this assurance, the BlueBoard tracks each content item as it comes into the system, tagging it with its owner's p-con ID. At badge-out time, all such content is explicitly removed (including items in the history list and any cookies that might have been created in the process).

### ***BlueBoard Knows its Place***

A BlueBoard is a relatively static device. Weighing in at somewhat more than 68 kilograms (150 pounds), it is not an easily portable pocket-sized gadget.

When the BlueBoard is not in use, we have found it useful to have it show a loop of content pages that are relevant to the location. In our meeting room setting, the BlueBoard puts up project web pages and other web sites of local interest (such as the IBM home page, the IBM research home page, news sites, etc.). The "attract loop" for page display is driven by a local list of pages that is tailored to the site and time. Pages are shown for a few seconds, then dissolve via an alpha-blend to the next page. When these pages are shown, the touch screen is still active. If a passerby finds the page of particular interest, just touch the screen, and the looping stops, giving full web browser capability. (We discovered that people often couldn't get to the board in time to stop the display. So we added a "back" button in the lower right corner, which works in the way you'd expect.)

We are working towards giving the BlueBoard a better sense of where it's located. Ideally, location information would be determined by a locator beacon (e.g., a in-room BlueTooth device) and then used to determine what pages would be of local interest. (Say, lab project pages would be shown on the lab BlueBoard, while corporate wide interest pages would be shown on a BlueBoard placed in the foyer.)

Similarly, we have done initial tests allowing people in a workgroup to email messages to the BlueBoard attract loop, much as was done in the Lens shared public display at Apple's research lab [6] .

### ***BlueBoard Users and Futures***

Our original design was intended to support very lightweight, spontaneous meetings of In prior studies we'd noticed that colleagues anytime and nearly anywhere (where there was a BlueBoard). In prior studies we'd noticed that colleagues often have spontaneous meetings – in hallways, at lunch, while passing someone's door – and people often wanted to be able to show something, take notes or sketch an idea quickly and without carrying a great deal of mechanism.

But this vision quickly ran into the realities of deployment and provisioning BlueBoards ubiquitously. We installed several, but were unsuccessful in reaching a critical mass. In retrospect, it seems that making large BlueBoards physically ubiquitous is probably unlikely given their size, weight and costs. So we have taken this observation to heart, and have begun focusing our design efforts on the support of working meetings – still lightweight in nature, but centered on meeting rooms and slightly less spontaneous meeting settings. This shifting in priorities has led us to begin working on using the BlueBoard as more of a shared collaborative resource, with everyone who is badged-in (either locally or remotely) being able to move content onto the BlueBoard (from their online networked content, or from a wirelessly connected computer) and off-of the BlueBoard (from the BlueBoard onto their wireless computer).

### **3. MERBoard: Original Goals**

The MERBoard, currently being developed at NASA's Ames Research Center, in collaboration with the Jet Propulsion Laboratory (JPL), is a tool to help scientists and engineers display, capture, annotate and share information to support the operation of two Mars Exploration Rovers (MER) on the surface of Mars in 2004. The MERBoard design was inspired by the Blueboard, from IBM Research. The designs of the Blueboard and MERBoard have diverged as the development of each responds to the needs and work practice of users in their intended domains. The current MERBoard design, intended to support tele-robotic science, is the result of a human centered development process. It incorporates both insights derived from ethnographic study and analysis and feedback from a participative design process.

The goal of the MERBoard is to foster collaboration among scientists and engineers as they analyze science data, develop science plans based on that data, and turn those science plans into commands that are transmitted to each of the MER Rovers for execution on the surface of Mars. As designers, we are striving for simplicity of use in the tool. Given the enormous amount of training and specialization already required for participants in the mission, our goal is to provide users with a tool whose basic functions and operations are quickly grasped, and one that can be used after 10 minutes of training.

### ***The MERBoard Domain - Mars Rover Surface Operations***

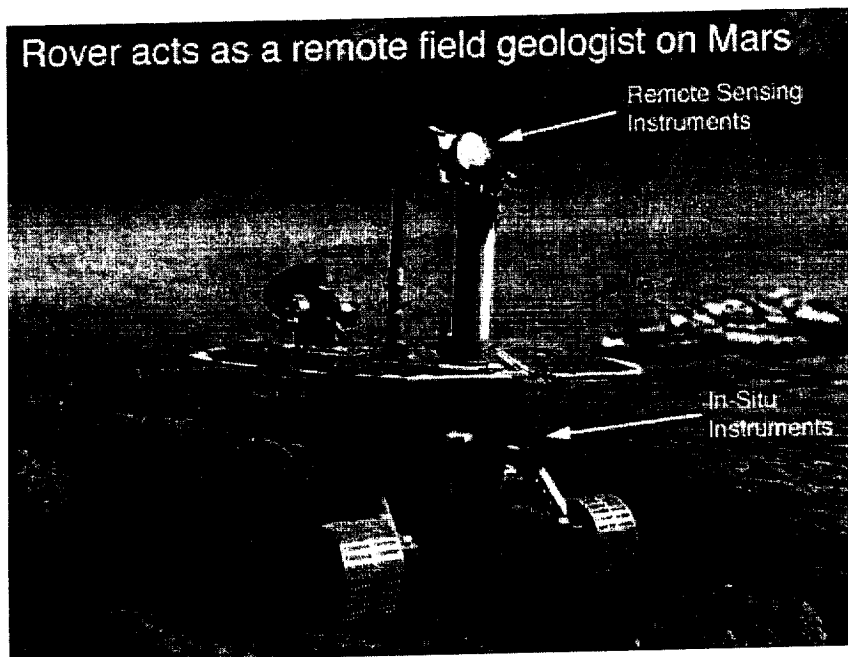


Figure 4 -- Mars Exploration Rover and science instruments

The MER Rovers will act as remote field geologists, providing scientists on Earth the ability to explore and learn about the Martian surface. Scientists and engineers will communicate with the rovers each day; analyze the data transmitted from the rovers to Earth; use that data to develop the strategy for what to study next; decide how to implement the strategy; and then send instructions for activities, in the form of commands, that the rover will implement. (Figure 5).

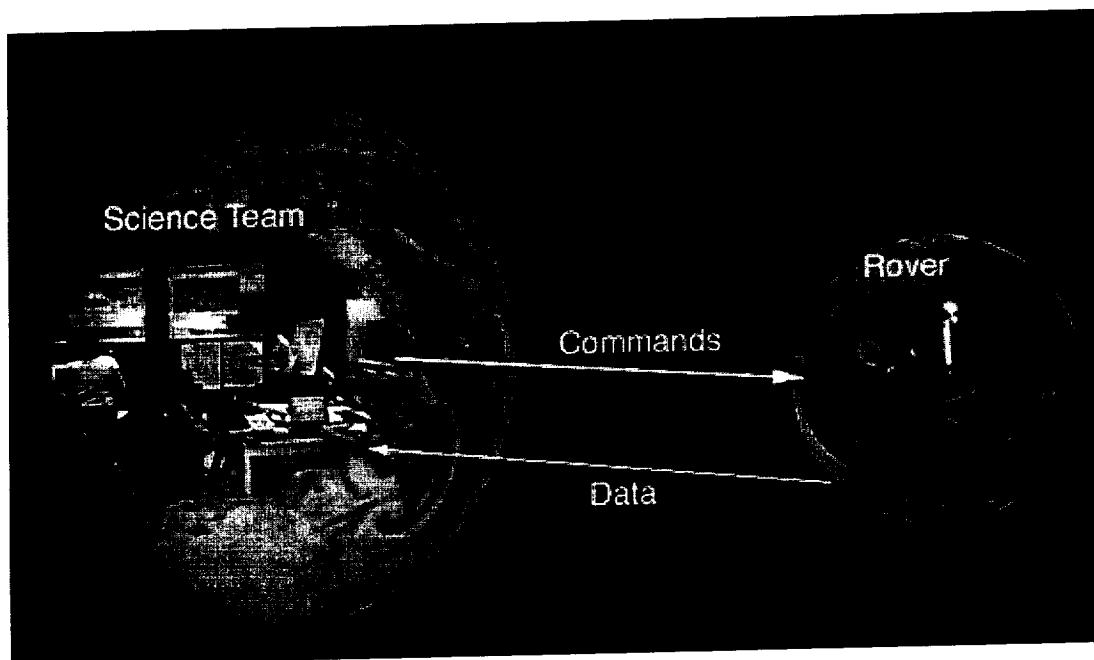


Figure 5 -- The rover operations team on Earth communicates with the rover on Mars every day

As shown in Figure 4, each rover has two kinds of instruments, one kind to conduct remote sensing measurements, the other for in-situ measurements. This allows the rover to operate in a manner somewhat

analogous to how a human field scientist would explore on the surface, viewing and analyzing the landscape from a distance (remote sensing), then deciding what to inspect more closely (in-situ).

The MER mission is now in development for a mid-year 2003 launch and surface operations in 2004. The surface operations will include the process in which engineers and scientists receive and assess the "downlinked" data, make decisions about what to do next, and "uplink" or send related commands to the rover. The work process, communication flows, software, hardware and operational interfaces between groups are currently being developed from documentation and requirements. Models of mission operations are being worked out in paper based designs.

A day in the life of the Mars Rover Surface Operations Team will begin with the receipt of data from the rover. Scientists will view and analyze that data and assess the resulting information to identify potential targets for inquiry. The science team will work in five different theme groups, atmospheric science, geology, geochemistry and mineralogy, soil/rock physical properties, and long term strategic planning. The theme groups must translate their inquiry into a strategy of prioritized scientific observations. The strategy will be formalized into representations for presentation to the engineers who will develop commands to carry out the requests. In order to do their job, the scientists will need to collaborate and make decisions within and across theme groups and as a team.

With each step in this daily process, the degree of formalism with regard to the science strategy increases. Early in the day new ideas for inquiry may be represented on flip charts and in notebooks. Then the scientists use the Science Activity Planner tool to turn the inquiry into complete observation requests, with instrument settings and parameters. By the end of the day, the ideas have been turned into formal representations that have moved through a variety of computer tools specific to each stage of the uplink process.

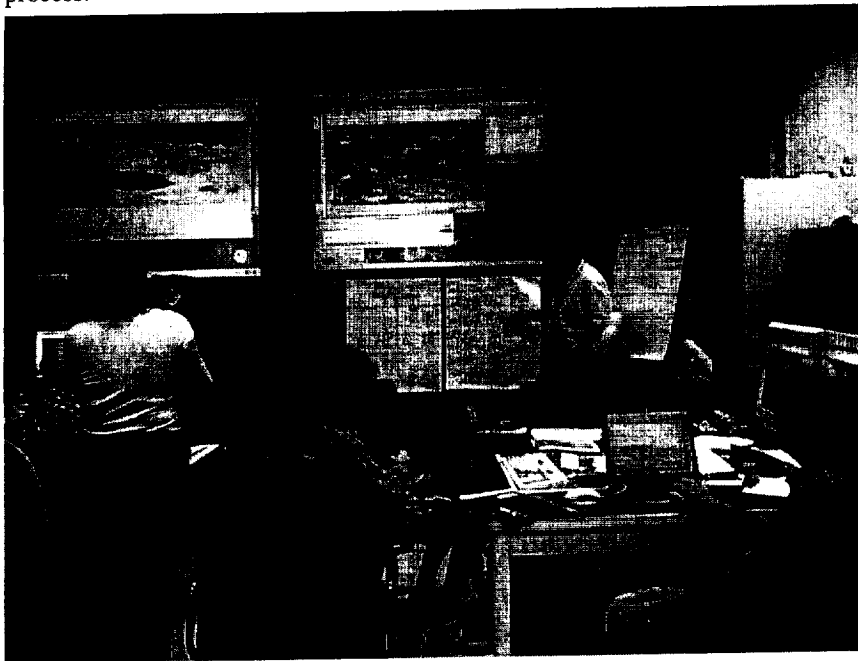


Figure 6 -- Scientists Training for Mars Surface Operations. The two large displays are just projections, not MERBoards. Note the actual interaction work is taking place on large pieces of paper attached below the projected image.

## ***Understanding and Augmenting Work Practice with HCC Methods***

As Human Centered Computing (HCC) Researchers, our goals for the mission are to increase mission safety and science productivity by working with the mission team to design tools and procedures that help the users accomplish their tasks, while minimizing the complexity of the tools. To achieve this for MER, we model and characterize user work practice based on data gathered in interviews, observations of training exercises, researching requirements documentation, and our own participation in parts of the design process.

Figure 6 shows the science team at work in a series of Mars Yard and “field” tests that took place in 2001. The tests simulated the process of doing tele-robotic science, commanding a remote rover and collaborating to make science decisions. Note the use of flip charts, laptop computers, print outs and projection screens that display information from the team’s Science Activity Planner tool.

Ethnographic observation and analysis, as well as interaction analysis [XX] of video or film taken during the above field test simulation, revealed limitations on the collaborative process. Specifically, we saw limitations on the ability of scientists to display, share and view important information, and limitations on their ability to save information. For example, the flip charts preserve the ability for natural, rapid, handwritten representations, and they are large enough to present to small groups of people who are co-located. They do not allow for the embedding of related information, such as images. They are difficult to store and retrieve over long periods of time, and they are not easily shared beyond team members who are in close viewing range.

In another example, scientists often had important supporting data on their laptops they could not share in a form the rest of the team could see. In Figure 5, the projection screens facilitated group viewing of some information in the computer tools such as the Science Activity Planner, but they were not configured to allow users to show their laptop data on the large projection screens.

The MERBoard design is intended to assist the mission operations process by addressing direct user needs that we observed in training, such as the ability to display, annotate and share information in a natural way, much as the team was already doing with flip charts. By inserting the MERBoard into the mix of tools shown in Figure 5 above, we propose to augment the teams existing work practice and to provide additional functionality that could enhance the science process.

The initial MERBoard design was developed based on an analysis of observations similar to those described above. With the HCC method, we can identify user needs and even propose new work process – we cannot predict with certainty all the effects of the introduction of a new tool into the mission operations process. Users will soon be able to test the prototype designs and will be able to provide us with direct feedback. As the MER Team begins formal training in 2003, they will be able to use the MERBoard in scenarios that simulate the mission. The MERBoard design team will observe this process to evaluate the impact of the MERBoard on work practice, as well as to assess the effectiveness of our HCC design process.

### **3.1 The MERBoard for Mission Operations**

The MERBoard hardware consists of a commercial off the shelf 50” plasma display with a touchscreen overlay and custom designed stand. The current software version consists of a Web Browser for data and file viewing, a workspace application that allows users to display and annotate images or any data displayed on the screen, a virtual network computer (VNC), a screen capture tool, and personal account space accessible on any networked board.



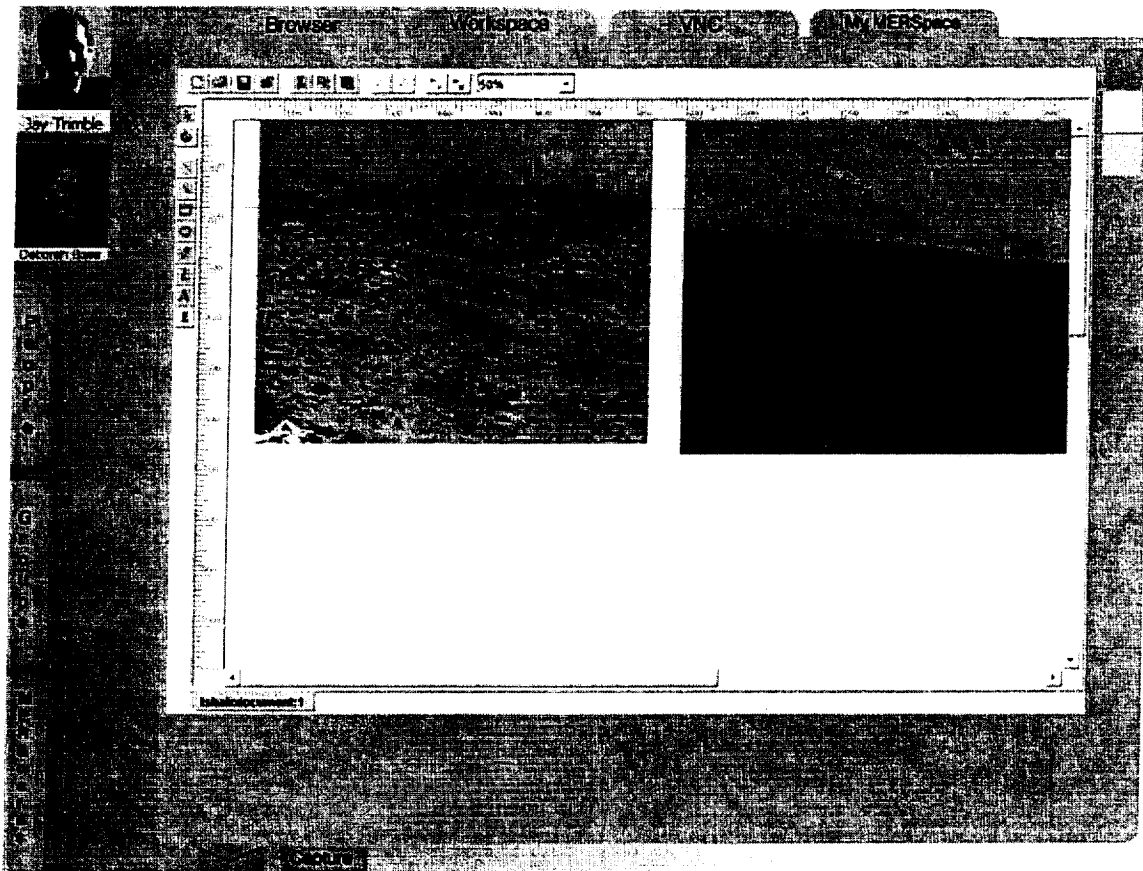


Figure 7 -- The current MERBoard UI Design

Figure 7 shows the current MERBoard user interface design. The tabs on top allow a user to select the browser, the workspace, the virtual network computer, or their own personal MERSpace files. On the right are color coded "stickies". The tabs on the left provide access to users, groups and other MERBoards. On the bottom, are the icons for the mail and screen capture tools.

Figure 8 shows the MERBoard hardware, the large plasma display with touchscreen overlay, and a specially designed rolling stand. A keyboard and mouse are currently being used for evaluation purposes, but are not considered necessary to operate the board, as the touchscreen is the primary input method.

### ***Viewing and Real Time Sharing of Data***

The MERBoard by virtue of its large plasma display, makes information easily visible to groups of people close to the board. The VNC allows any user on the network to view the contents of any MERBoard, either from their own personal computer, or from another MERBoard. With VNC, team members will be able to display and share the scientific data on their laptops with the larger group. Additionally, VNC extends data viewing and sharing throughout the mission support area and makes one group's data accessible to all team members. With the MERBoard, scientists can view the work of the other theme groups, enhancing information sharing and expanding the knowledge base for the whole group. In principle this sharing capability can be extended to remote sites, providing team members who are not in the primary mission support area at JPL the ability to participate in the mission process.

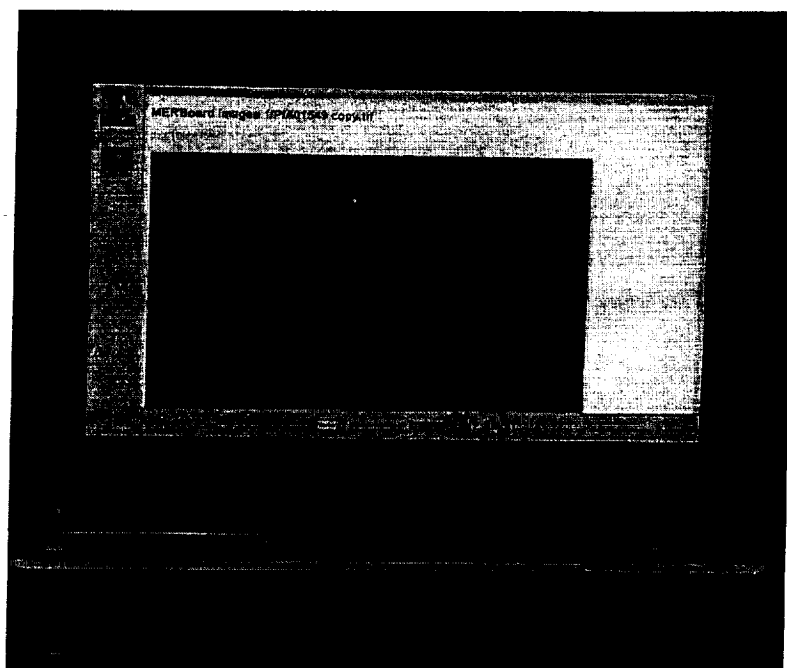


Figure 8 -- MERBoard Software on large plasma display with touchscreen overlay

### ***Viewing Data and Data Annotation***

The MER Science Team will analyze images and other data on a daily basis. They will view images of the Martian landscape to determine where they would like the rover to go and what features, rocks, cliff face, soil etc., they would like to analyze with their instruments. They will also view images representing multiple scales of representation from panoramas of landscapes to microscopic images of selected features. After they analyze data, they will develop hypotheses, select new targets for inquiry, and implement science observation strategies to get data from those targets.

The MERBoard is designed to facilitate easy capture and display of multiple images. While much of the science analysis will be done in the science activity planning tool, the MERBoard workspace will make it possible to compare and annotate images, either free hand, with a limited set of drawing tools, or with voice annotations. We believe, the ability to support natural annotations and link it to information will contribute to the decision making in the next step in the process, which is the formal specification of science data requests.

Figure 9 shows one example of work practice from the field tests. Team members referenced print outs of large images in the mission support area, using various improvisational devices to point to and reference different details of the image. While we believe that the scientists will still want to look at large printed images in the mission support area, we also believe that the MERBoard, by allowing for the electronic display, annotation and referencing of images of different sizes and resolutions, has the potential to increase the science team's productivity and aid the decision process.

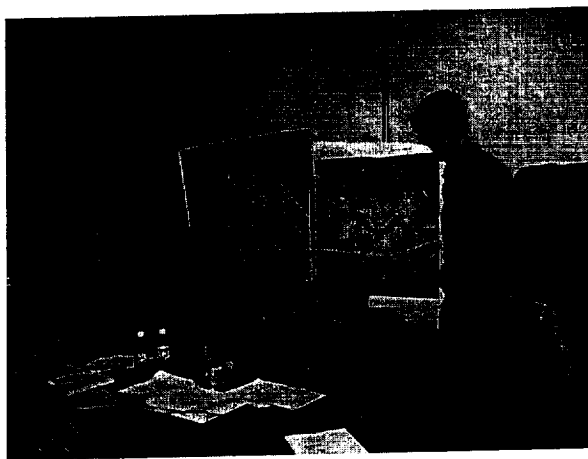


Figure 9 – Science teams working with large (offline) photos. Form factors count for a great deal when working in with many people on large amounts of visual data.

### ***Sending and Saving Data***

The MERBoard design has several mechanisms that allow for easy sending, saving and retrieval of data.

*E-mail:* Pages from the MERBoard's workspace may be easily e-mailed to any other MERBoard user with a simple drag and drop interface. The scientists already have email accounts and presumably check them regularly. This functionality leverages existing software systems and knowledge. No new software development or training is required in order for scientists to be able to share information with team members who are not present.

*Save to MERSpace:* Each MERBoard user has an individual storage space on the MERBoard. This space is accessible from any MERBoard with a simple log in, and is also accessible from a MERBoard Client. Users may save data to their own MERSpace with a simple drag and drop. The current interface does not allow users to save information to another person's MERSpace as our current working assumption is that users are unlikely to regularly check their MERSpace in-box for data sent from others; e-mail is used for this purpose

*Save to an Archive:* During and after the surface operations of the mission, it is highly likely that scientists will want to retrieve information that allows them to recreate the context of events and support their analysis of mission data. Also, MER is an historic mission and it will be important to retain documentation to understand the scientific process and recreate a mission history. Additionally, because this is a research project, we must offer several ways for scientists to save data in order to evaluate what was useful for participants during the mission. Therefore, we will provide a functionality that allows group members to save data with key words as well as "metadata" that already exists in the board. Examples of meta-data include time, location and name of the board, date, Martian Sol (a Martian Sol is the rough equivalent to an Earth day, i.e. a Sol is 24.7 hours), and other parameters that do not require users to specify them.

## **4. BlueBoard: Lessons Learned from Early Testing**

In normal use, the BlueBoard is a place where a small number of people can quickly and easily work together. A major question is what would actually happen in small group use.

We ran a field study of the BlueBoard in use by small groups at a workshop held at the IBM Almaden site. Badges were given to 163 participants, 90% from outside of IBM or Almaden, and with no advance knowledge of the test. The database was initialized with their email addresses and pointers to their home pages.

At the beginning of the workshop, a brief 4 minute demonstration of the BlueBoard was given to all participants simultaneously, and the BlueBoard was made available in the hallway immediately outside the auditorium for non-directed use during the breaks and an extended lunch. (The BlueBoard was one of many demonstrations in the hallway.) The instruction covered badging-in, access to one's home page

through the p-con, exchanging URLs, use of the whiteboard tool, sharing whiteboard content between badged-in people, and badging-out to cause shared content to be automatically emailed away.

Users of the BlueBoard were videotaped in use, and six were given a post-use informal interview that asked questions about their goal in using the board, particular problems they had, and possible future extensions.

During the 110 minutes of BlueBoard availability, it was nearly constantly in use as participants would walk up, badge-in and begin exploring its capabilities. Although no task was set, we saw several apparently authentic work uses of the board during the time we observed. These included demonstrations of participant website development ("let me show you this great thing I did.."), explicit sharing of web pages, and uses of the whiteboard for non-trivial diagrams.

After the workshop, we collected our field notes and analyzed the video.

As would be expected, we learned a number of pragmatic user interface lessons from our observations: inconsistencies in the UI widgets and idioms, the particular difficulty of using a touch screen with long fingernails (they generate an uncertain touchdown point on the resistive touch sensor), how high we can place elements on the screen to be used by short people, and so on.

### **Observations on Group Use**

Although we were initially simply looking for instances of authentic work-like uses of the BlueBoard, and the degree to which all the BlueBoard features could be used after such short instruction, we were struck by the number (and importance) of social interaction effects that took place. Here are the six most evident effects we noted in our analysis:

*1. Social learning through exposed interaction:* The interface style of the BlueBoard is evident – a user can only touch parts of the display to make things happen. Consequently, the entire interaction process is visible to everyone -- there are no hidden keystrokes or sudden mouse movements that are difficult to understand. Participants who are unsure of how to use a particular function of the BlueBoard were able to very easily see how someone else could do the thing they wanted. In the course of study, we saw many examples of someone picking up a behavior by seeing someone else use it in the course of their interaction.

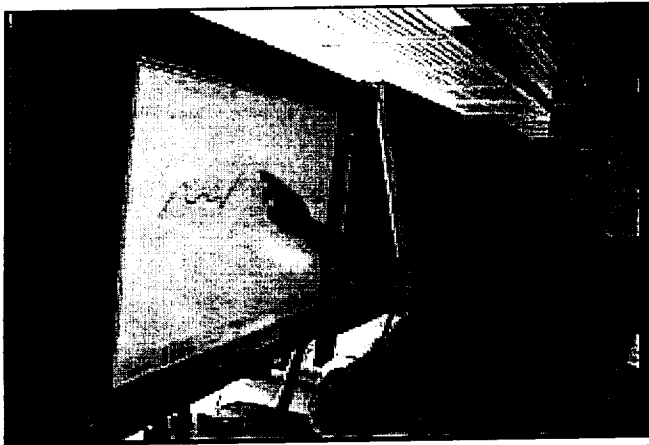


Fig.4. BlueBoard setup in the field study. The whiteboard tool is always one touch away from instant use. The image can be dragged onto the artist's p-con or onto another p-con to be emailed when that person badges-out. In this video sequence, the user controls the use of the board while three other users watch, waiting their turn.

*2. Etiquette of multiple person use is unclear:* When a group was using the BlueBoard, other participants were often uncertain about what kind of behaviors would be acceptable. Should one badge-out while another person was engaged in making a point? Was it permissible to badge-in without making any kind of verbal comment? Time and again we saw hesitations as new BlueBoard users struggled with these momentary crises. Similar issues arise in any kind of workgroup that is focused on a shared information resource (including non-electronic) – what are appropriate behaviors for engaging and disengaging? [11]

We believe these questions will subside over time as board use becomes more commonplace and practices evolve. (See Figure 4.)

3. *Who drives?* Groups using the BlueBoard often tended to have one person dominating the interaction. Usually, this was the person doing work at any one moment, either by showing group members their content, navigating to a web page to show a result, or working on the whiteboard. Less frequently, but encouragingly, we also saw several instances of small groups (2 – 4 people) where there was NOT an obvious group leader. These more cooperative discussions were almost exclusively whiteboard drawing sessions where turntaking was rapid and fluid.

4. *Learning to work together – evolution of turn-taking:* It happens that the BlueBoard touchscreen cannot handle more than one touch point at a moment. If two people touch the screen simultaneously, the cursor jumps to the midpoint between them. When two people are using the whiteboard tool together, it is immediately obvious to the drawers that this is true, and a turn-taking practice rapidly comes into place. We note with some satisfaction that complex floor controls were never asked for nor needed. Instead, because the people drawing could immediately see the consequences of their actions, and because they were physically adjacent, they could easily tell when their partner was about to draw and coordinate their joint actions.

5. *Reaching across:* The size of the BlueBoard is an important determiner in the way groups of people work with it. In the small dynamic workgroups, 2, 3 or 4 people would stand effectively shoulder-to-shoulder, each person reaching in to touch and operate the BlueBoard. By contrast, when a single person was leading the discussion, they would tend to stand in front of the board with other members (from 1 to 5 others) making an arc in front of the board. We noticed many instances of hesitation when controlling the board required reaching across another person standing in a controlling position. That is, like reaching for a plate at the dinner table, participants considered the reaching maneuver to be perhaps slightly rude – and an assertion of control over the proceedings.

6. *Group sharing of information:* As others have pointed out, shared information artifacts need not be electronically based, but simply available to many people simultaneously. [11] When such shared displays are being created and edited in real-time, there is a distinctly opportunistic use of the information being used in the meeting. Even when a single person is controlling the flow of events, being able to share the experience of editing *in situ* provides additional important side-channels of information exchange. In our study we noted several instances of side-comments being incorporated into the flow of the discussion; comments that might have never been a part of a virtual discussion.

## Observations on Individual Use of BlueBoard

In addition, we had several observations about individual uses of the BlueBoard.

1. *Text input:* Although participant home pages were not optimized (or even minimally set up to take advantage of the BlueBoard), it didn't seem to matter except in cases when text input was required for search or login. Since search strings tend to be short, a virtual keyboard of some kind will suffice. But login authentication requires typing in a password, and as noted above, a BlueBoard / LISA class device is particularly accessible for co-participants in a group setting. In the field study, no keyboard was available, so participants simply did without, but it is a problem that will have to be resolved.

2. *Drawing is important:* The whiteboard tool was put into the BlueBoard initially as a small drawing capture area. Over time, though, we have been consistently surprised at the utility of the whiteboard tool and the novel uses people have found for it. While the whiteboard tool is currently very simple (simple vectors drawn point-to-point by finger-dragging), the simplicity of the tool, its attractive similarity to fingerpainting, and most importantly, its automatic capture via being emailed as an attachment, all led to a wide number of uses. One of the unexpected uses noted during the field study was the number of times people would write their email address and drag it to an acquaintance's p-con. This would effectively send the recipient an image with an email address in it – quickly and simply, all without typing. (Similar instances of people scheduling appointments by writing times, dates and places were also seen.)

3. *Easy to use:* Of the six behaviors shown in the introductory four minute demonstration, we saw all of them in competent use by first-time users. Some of the skill users demonstrated was clearly due to social

learning through observation, but we were pleased to find that the affordances of the interface were fairly apparent.

4. *Few badge-outs*: On the other hand, the one behavior that was problematic was badging-out when leaving the BlueBoard area. Nearly everyone who had done some work (e.g., created a whiteboard image or saved a URL to their p-con) successfully badged-out. But around 50% of those that did not capture an image or other content failed to badge themselves out of the BlueBoard. (The number is approximate, plus-or-minus 10%, because we did not accurately track badge-out events.)

## 5. MERBoard: Lessons Learned from Early Testing

### *Initial User Reactions*

We introduced the first version of the MERBoard tool to many of the scientists who will participate in the MER mission at a meeting in January of 2002. After demonstrating the functionality and operation of the tool, we invited participants to use it and offer comments.

Generally, participants were enthusiastic about the ease of use and were impressed with the large plasma display. One participant even quipped, "How much do these things cost? I want one in my office." The science team documentarians quickly saw ways that the board could enhance their work with the addition of functionality that would allow them to package and group documents and images.

Other users were enthusiastic because they saw the board's possibilities as a remote collaboration tool, believing that it could provide them with access to updated information on the progress of the mission while at home. Because of security issues during the mission, however, we do not know whether the tool can be used for remote collaboration.

Team members were more cautious about the tool's design and benefit when it came to logging in and sharing space. Because of the large number of team members who might be using a board at any given time and the fact that they would work in groups, they had questions about the log in process, the use of "P-cons," and how the team would use the tool when several people were participating in the discussion, sharing a workspace and annotating data. They were undecided as to whether they needed the ability to track and identify individual annotations and changes in the information. Some scientists wanted the ability to save annotated data to an archive; others did not. There was a discussion about the possible challenges of making group decisions with regard to saving or deleting shared information.

Some participants liked the ease of sending information from the board via email. Others were openly skeptical about the value of getting more email. They were more receptive to a proactive approach that would let them go and get the information they wanted from an archive.

There were questions about how individuals could prepare and post information to the board for later display, questions about how the client version of the software would work, and security questions in regard to VNC.

We got many UI comments. Users wanted:

- feedback that let them know that an action has been accepted
- an undo button
- different placement of tabs and buttons
- double touch actions, as well as drag and drop capability
- grid lines to keep the writing neat so that it was easier to read later
- rulers for measurement

As observers, we noted that participants had some difficulty using the plasma display. People had to learn how hard to press on the board, how to write and annotate easily, how to use finger touch in scrolling.

All of this feedback has been considered in later design decisions.

## 6. Common Lessons

Differences between MERBoard and BlueBoard stem primarily from the two vastly different intended user groups and their expectations for work group support.

*Differences:* The BlueBoard has no keyboard, and in some installations is located in a passageway without a place to sit or work for extended periods. The expectation originally was that BlueBoards would be used largely for ephemeral purposes – for spontaneous demonstrations or rapid access to information for immediate use. By contrast, MERBoard is aimed for work sessions that may last for extended periods of time, with a fairly limited and technical user audience. The kind of work practiced by the NASA team is fundamentally different than that of BlueBoard users – it centers on accessing content, then annotating it and linking content with other pieces of information, storing and retrieving data, as well as on display and information sharing among and between groups. As a consequence, several of the design decisions made by BlueBoard (lack of keyboard, unavailability of remote computer access, the use of p-cons for locally logged-in people) worked against the goals of the MERBoard users and needed rethinking. The workpractice that the MERBoard will support calls for more complexity in the conceptual model and in the design of the tool than is called for by the intended use of the Blue Board.

*Similarities:* Both projects had to rapidly evolve in the face of requirements to fit into the tasks of their respective working populations. In both cases, lessons learned during early deployment led to substantial changes in either the interface design (MERBoard) or the goals of the overall project (BlueBoard). While both projects continue to advance, it is clear that such analyses of fit-to-task and fit-to-overall-goal need to be evergreen reflective aspects of the project. In both systems, it has become apparent that no amount of upfront analysis would ever have been enough to pre-determine all of the requirements and properties that would be needed. A priori analysis is useful, but only in a systems development environment that *also* allows for significant changes to happen after actual first pilot testing results have been collected and analyzed.

## 8. Summary

It's clear that user-centered design is required for any kind of project that has a significant user-facing aspect. Even projects that seem superficially similar – such as supporting team work at NASA and for knowledge workers at IBM Research – turn out, in the analysis, to be significantly different. Those differences drive the evolution of the system. A key aspect in the development of these two systems has been a continuing theme of reassessing the design's fit to users and fit to task: such evolution needs to happen on a relatively rapid time scale in order to be useful to the user population and to retain interest and capability in deployment.

In the future, as MERBoard and BlueBoard progress and our understandings of the use patterns in each environment grows, we hope to find an increasing number of common shared ideas and user behaviors. This second level of analysis will, we believe, lead to the basis of a set of practices that will emerge in the area of publicly available, large, shared and interactive display surfaces.

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